Nanoparticles of IrO_2 on Synthetic Boron-Doped Diamond Surface

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INTRODUCTION

The determination of the electrochemical properties of supported oxide nanoparticles is of great interest for both fundamental and applied research.

The electrocatalytic active component for O_2 evolution electrodes is iridium dioxide (IrO_2). The oxide is deposited by thermal decomposition technique on titanium base metal. This base metal can influence strongly the electrochemical behaviour and stability of the deposited oxide catalyst.

The recent achievements in the preparation of Boron-Doped Diamond (BDD) thin film electrodes on Si substrate make BDD an interesting candidate as inert substrate in investigation of catalytic properties of nanoparticles.

In the present work, the electrocatalytic behaviour of IrO_2 nanoparticles, deposited on BDD substrate by thermal decomposition technique, is investigated.

EXPERIMENTAL

BDD thin film electrodes were synthesized by hot filament chemical vapour deposition technique (HF CVD) on single crystal p-type silicon. The as grown BDD was anodically polarised to obtain oxygen terminated hydrophilic surface.

IrO_2 nanoparticles were deposited on hydrophilic BDD substrate by thermal decomposition technique [1] using $H_2IrCl_6 \cdot 6H_2O$ in i-propanol as precursor salt solution. Two temperatures were used for the thermal decomposition in air (350 and 450°C).

The deposited amount of IrO_2 was varied between $6\ 10^{13}$ and $6\ 10^{15}$ molecules/cm^2 (geometric surface).

RESULTS AND DISCUSSION

Voltammetric charge of BDD/IrO_2 electrodes

Deposition of small amounts of IrO_2 clusters on the BDD surface (BDD/IrO_2 electrode) enhances dramatically the voltammetric response of the electrode in the potential region of water stability (Fig.1). The voltammetric (anodic) charge, obtained from integration of the anodic part of the voltammograms, provides a measure of the electrochemically active surface area.

The dispersion efficiency γ of the particles on BDD surface has been calculated as ratio of the measured voltammetric charge q* and the theoretical charge q_{th} for the charging processes, estimated from Faraday's law. The dispersion efficiency improves with decreasing deposited amount and increasing temperature.

Electron transfer on BDD/IrO_2 electrodes

The irreversible behaviour of the couple 1,4-benzoquinone/hydroquinone (Q/H_2Q), remarked on BDD electrode, dramatically changes on BDD/IrO_2 electrodes. Increase in IrO_2 amount increases the reversibility of the couple (Fig.2). Presumably IrO_2 particles have an electrocatalytic effect in charge transfer reactions on BDD electrodes.

Oxygen evolution reaction

Small amounts of IrO_2 deposited on BDD surface decrease the overpotential for the oxygen evolution reaction (Fig.3). The fact that BDD/IrO_2 electrode behaves similar to IrO_2-DSA® type electrodes suggests that IrO_2 clusters on BDD surface act as redox catalysts in oxygen evolution [1].

REFERENCES

[1] I. Duo, P.-A. Michaud, W. Haenni, A. Perret and Ch. Comninellis, Electrochem. and Solid State Letters **3 (7)**, 325-326 (2000).

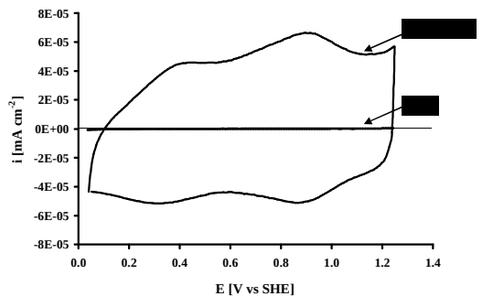

Fig.1 Voltammograms of BDD and BDD/IrO_2 ($1.3\ 10^{15}$ molecules/cm^2). 1M H_2SO_4. 3V/s

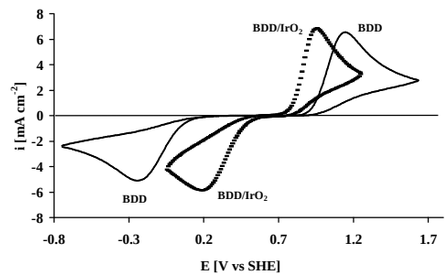

Fig.2 Q/H_2Q couple on BDD and BDD/IrO_2 ($6\ 10^{15}$ molecules/cm^2). 1M H_2SO_4. 50 mV/s

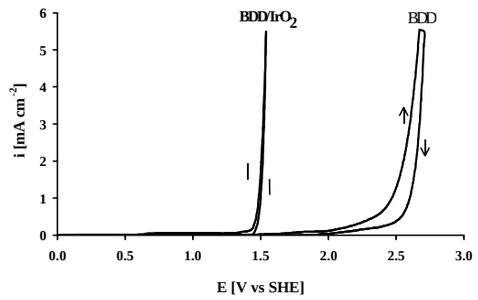

Fig.3 Oxygen evolution at BDD and BDD/IrO_2 ($6\ 10^{15}$ molecules/cm^2). 1M H_2SO_4. 50 mV/s